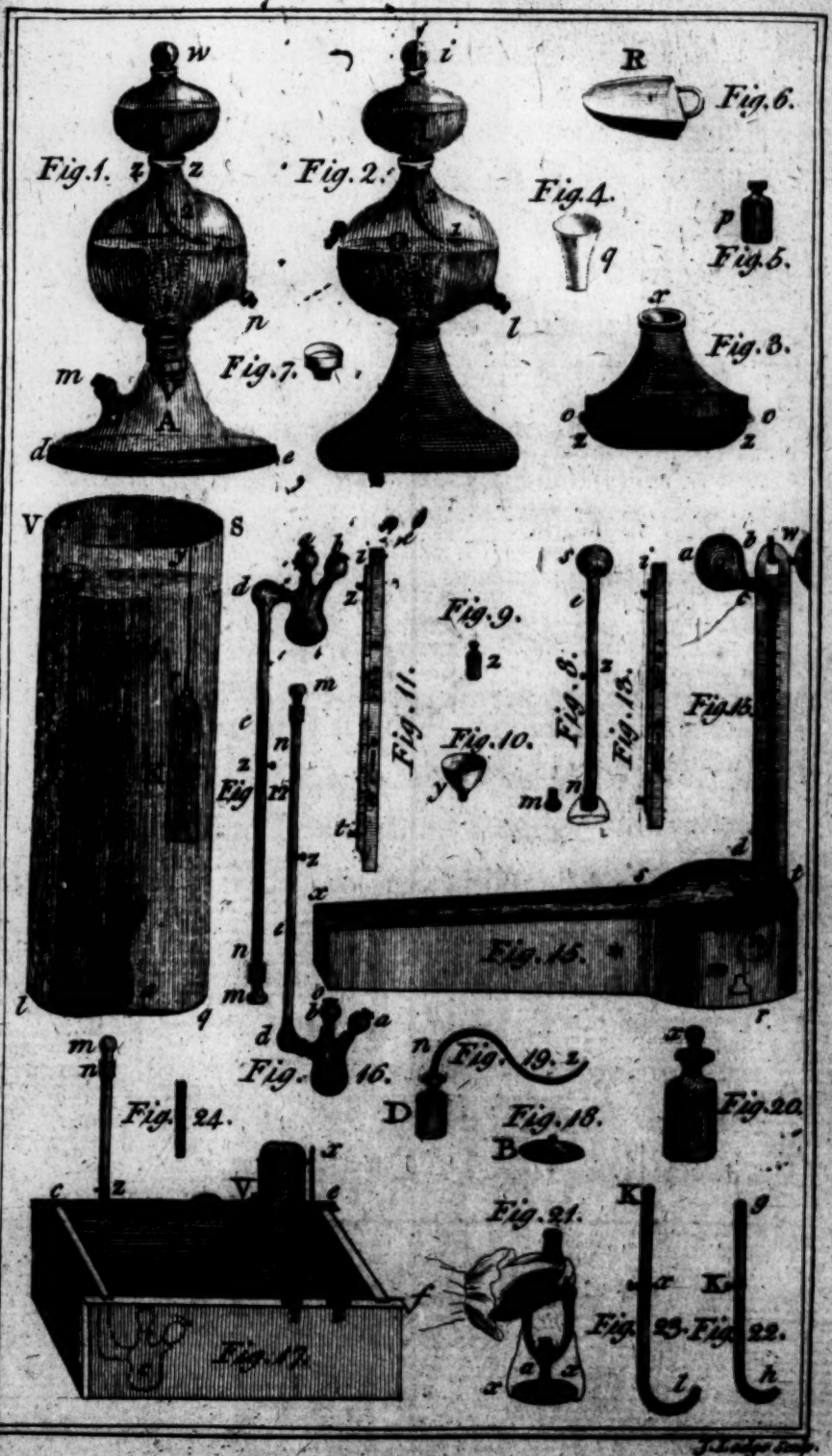
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Fig. 12.
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Fig. 21.
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Fig. 23.
Fig. 24.
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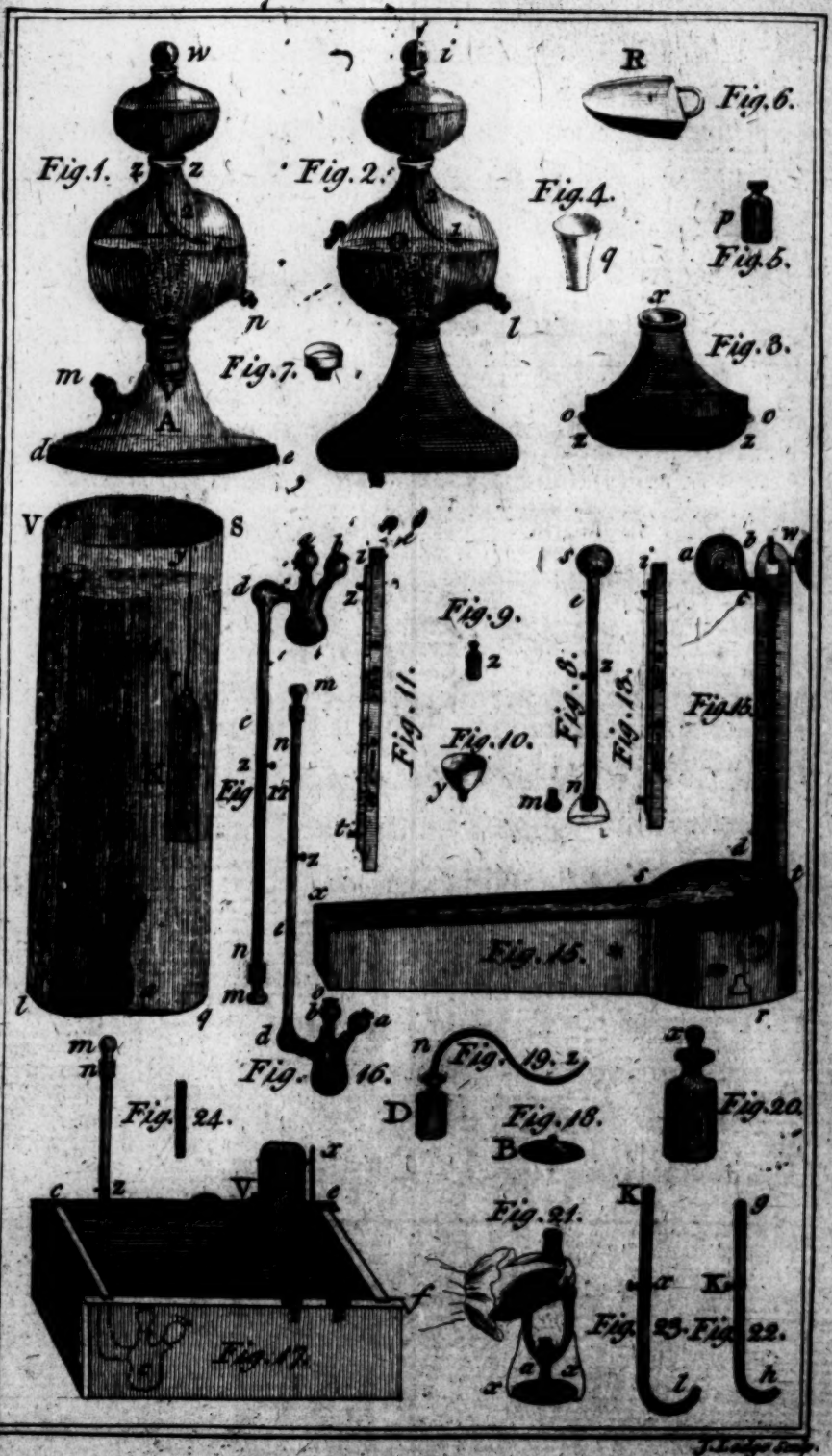
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5

DESCRIPTION

OF A

GLASS APPARATUS,

FOR MAKING

MINERAL WATERS,

LIKE THOSE OF PYRMONT, SPA, SELTZER, &c.

In a few Minutes, and with a very little Expence:

TOGETHER WITH THE DESCRIPTION OF SOME

NEW EUDIOMETERS,

OR

INSTRUMENTS for ascertaining the WHOLSOMENESS of

RESPIRABLE AIR;

AND THE

METHOD OF USING THESE INSTRUMENTS:

IN A LETTER TO THE

REV. DR. PRIESTLEY, LL.D. F.R.S.

BY J. H. DE MAGELLAN, F.R.S.

K

LONDON:

PRINTED FOR W. PARKER, No. 69, FLEET-STREET, AND SOLD BY J. JOHNSON, No. 72, ST. PAUL'S CHURCH-YARD, AND W. BROWN, THE CORNER OF ESSEX-STREET, IN THE STRAND.

MDCCLXXVII.

ADVERTISEMENT

OF THE

EDITOR,

RELATING TO THE USE OF THE SIMPLE GLASS MACHINES FOR MAKING MINERAL WATERS.

ALTHOUGH the method of uſing the ſimple glaſs machines of Mr. Parker, is minutely deſcribed in the following Letter, nevertheleſs it may be more agreeable to find here diſtinct references to thoſe articles, where it is particularly contained; as the Author ſeemingly could not help blending it with that of his improved machines.

I. The deſcription of the ſimple Parker's machine is compriſed No. 5 and 6.

II. The proceſs to make uſe of the ſame, is deſcribed No. 9, 10 and 11.

III. The manner of carrying on the production of *fixed air*, is indicated No. 14 and note (*d*).

IV.

IV. The method for reducing the proceſs to a few minutes is deſcribed No. 12, 13 ; ſee note (*c*) and No. 15.

V. The manner of keeping theſe acidulous waters is ſhewn No. 16.

VI. For making them ſparkle like Champaign wine, No. 17.

VII. For making them ferruginous or chalybeate, No. 18.

VIII. As to the medical and œconomical application of theſe waters, and *fixed air*, ſee No. 1, 3, 19 and 20.

N. B. *Both* glaſs-machines, *for making artificial mineral waters, and the* Eudiometers *here deſcribed, are made and ſold at W. Parker's cut-glaſs manufactory, No.* 69, *Fleet ſtreet, London.*

ERRATA.

Add to the end of page 3, theſe words, *See Withers's Obſervations on Chronic Weakneſs*, page 164, York, 1777, in 8vo.

Page 39, laſt line but one : *two or three* ; read *one or two.*

Page 45, about the middle : $\frac{188}{100}$; read $\frac{198}{100}$.

THE

CONTENTS.

ON ARTIFICIAL MINERAL WATERS.

ON EUDIOMETERS.

Niceties

De-

TO

TO THE

REVEREND DR. PRIESTLEY.

DEAR SIR,

I Do not know how better to employ the leiſure of theſe holydays I enjoy in your neighbourhood, than in deſcribing, according to my promiſe (*a*), the two contrivances I have mentioned in my laſt letter; which, I hope, will be uſeful to the public. It is with pleaſure I have obſerved a great agreement in almoſt all our philoſophical ideas: but I am very happy to find that we agree ſtill more, in

(*a*) This refers to a former letter to Dr. Prieſtley, printed in the Appendix to his third volume of *Experiments and Obſervations on Air*, No. III, p. 376 of the London edition.

looking with the greateſt indifference on any diſcovery, even the moſt ingenious, if no real advantage may accrue from it to mankind. Amongſt the many that you have made, and which are ſcattered in your Philoſophical Works, that of producing by art, at any time or place, with very little expence and trouble, Mineral Waters, like thoſe of Pyrmont, Spa, Saltzer, &c. whoſe virtues depend on their being impregnated with *fixed air*; and that of finding out a general ſtandard or teſt for aſcertaining the greater or leſs ſalubrity of reſpirable air, in any place whatſoever, are, undoubtedly, the moſt beneficial. The ſucceſs with which the firſt of theſe two diſcoveries is employed, wherever it is known, and the very intereſting obſervations relating to the ſecond, made almoſt all over Italy by the Chevalier Landriani, with his Eudiometer, clearly evince the truth of my aſſertion.

2. As ſoon as your pamphlet, containing the method of making Pyrmont Water, fell into my hands, in the year 1772, I ſent abroad a great many copies of it, to different parts of Europe, where I have a literary correſpondence; this having long been my cuſtom, whenever any uſeful diſcovery comes to my knowledge. I made then ſome change or improvement in your method, which rendered

the manner of conveying the fixed air to water ſomewhat eaſier. This was added in a note to the French tranſlation of it, made ſoon after at Paris, from a copy that I had ſent to that great promoter of Natural Philoſophy, Monſieur Trudaine de Montigny, mentioned page 268 of your ſecond vol. on *Different Kinds of Air*. Sometime after, Mr. Blunt invented a machine, which rendered this operation ſtill more eaſy. One of this kind, made by himſelf at Mr. Nairne's, I ſent to a very judicious lover of philoſophical experiments at Turin, the Marquis de Roſignan; now ambaſſador of the King of Sardinia to the court of Berlin.

3. Another conſtruction of a glaſs machine for the ſame purpoſe, was publiſhed by Dr. Nooth, in the 65th vol. of Philoſophical Tranſactions. But this being very imperfect, was afterwards improved by Mr. Parker; and you have given an account of it in the ſecond volume of your work, above mentioned, page 298, and following. A very great number, above a thouſand, of theſe machines have been ſent to different parts, even to the Eaſt Indies: and it is known that many perſons have been greatly benefited by the uſe of theſe artificial acidulous waters.

4. I found, however, not long ago, that the manner of conducting the proceſs, as deſcribed in the printed directions ſent with theſe machines, was very inconvenient, on account of its ſlow operation; it requiring four, and even ſix or ſeven hours to get the water fully impregnated with fixed air. This I felt the more in November laſt, on my being at his Serene Highneſs's the Duke of Arenberg, whom I have a right to call my Mecænas, on account of the many favours I have received from him. Knowing this generous Prince to be endowed with the beſt diſpoſitions that any of his rank ever had, for encouraging and giving his protection to all improvements and diſcoveries beneficial to mankind, this conſideration prompted me to ſend from London one of theſe improved machines to Bruſſels for the uſe of his Highneſs; and, on my trying it, on my arrival there, I felt, for the firſt time, how diſagreeable it was to wait ſo long for the deſired effect; which could be ſoon compleated, if the firſt method already mentioned, No. 2, was employed: for which reaſon I always had made uſe of this laſt, in preference to any other; as it requires but few minutes to compleat the operation. I then conſidered what could be done to avoid this. At laſt I contrived the following apparatus, conſiſting of ſome additional pieces, by which means the whole

whole operation is ſo ſhortened, as to take but few minutes: and, at the ſame time, the quantity of the artificial water is increaſed to double of that which is impregnated, at one proceſs, in the ſimple glaſs-machine, improved by Mr. Parker.

A Description *of this* Apparatus.

5. Let A B C (fig. 1,) be one of the improved machines of Mr. Parker, ſtanding upon a wooden diſh *d e*, in order to avoid any water, if ſpilled, from falling on the table. The middle veſſel B has a neck, which is inſerted into the mouth of the veſſel A, being nicely ground air-tight to it. This lower neck of the middle veſſel B has a ſtopple V of glaſs, compoſed of two parts, both having holes, ſufficient to let a good quantity of air paſs through them: between theſe two parts is left a ſmall ſpace, containing a plano-convex lens, which acts like a valve, in letting the air paſs from below upwards, and hindering its return into the veſſel A.

6. The upper veſſel C terminates below in a tube, marked 2, 1, (fig. 1,) which being crooked, hinders the immediate paſſage of the bubbles of fixed air into the upper veſſel C, before

before they reach the ſurface of the water in the veſſel B. The veſſel C is alſo ground air-tight to the upper neck of the middle veſſel B; and has a ſtopple *w*, fitted to its upper mouth, which is perforated through the middle. This upper veſſel C contains juſt half the water that can be contained in the under one B; and the end (1,) of its crooked tube (2, 1,) goes no lower than the middle of the ſame veſſel B.

7. Beſides theſe, I have added the two other veſſels, G and H (fig. 2,) perfectly like thoſe marked *B* and *C* (fig. 1,). The veſſel H is furniſhed with a ſtopper *i*, equally perforated as the other *w*, and contains half as much as the veſſel G. Theſe veſſels are ſet upon the wooden ſtand F: and the lower neck of the veſſel G is not only furniſhed with a valve and ſtopple, as already deſcribed in the veſſel B, but is fitted and ground air-tight to the neck of the ſame veſſel A. Each of the three veſſels, A, B, and G, have an opening, *m*, *n*, and *l*, with ground ſtopples, which are only open when occaſion requires, as will be mentioned hereafter.

8. I contrived the wooden ſtand K, (fig. 3,) ſo that a thick piece of glaſs *x*, like a ſmall tumbler, be cemented in the top, after it has been

been ground air-tight to the under necks of the veſſels B and G. The form of this ſtand is eaſily conceived by the engraved plate, fig. the 3d; it being plane at the bottom, turns up in a kind of convexity *z z* towards its edge, and has a round moulding *o o*. Figure the 4th repreſents a wide glaſs funnel *q*, which may enter into the upper mouth of the veſſel A. Figure the 5th repreſents a ſmall phial *p*, which ſerves to meaſure the quantity of the vitriolic acid to be made uſe of. Fig. the 6th repreſents a little trough of tin R, to meaſure the pounded chalk or marble, that is to be employed in every proceſs: and fig. the 7th repreſents a particular kind of ſtopples, the uſe of which will be explained hereafter.

THE PROCESS.

9. Let ſome dry chalk, as it comes out of the earth, that is to ſay raw, and without being burned in the fire; or rather white marble, which is much better for the purpoſe (*b*), be reduced

(*b*) White marble being firſt granulated, or pounded like coarſe ſand, is much better for the purpoſe, than the pounded chalk: becauſe the action of the diluted acid upon the marble laſts a very conſiderable time; and the the ſupply of the *fixed air*, which is diſengaged by this effer-

reduced to powder; and let ſome oil of vitriol be at hand. The veſſel *B*, together with *C*, (fig. 1,) muſt be taken off from A, and put into the ſtand *K* (fig. 3,). The veſſels C and H being ſeparated from their under ones B and G; let theſe laſt be filled with ſpring, or any other drinking water, or even with diſtilled water; and let them be joined again with the upper veſſels C and H.

10. Let ſome water be poured on the lower veſſel A, ſo as to cover the riſing part of its bottom: but if this appears too vague a direction, pour in fourteen or ſixteen meaſures of water, with the glaſs *p* (fig. 5,): then fill the ſame phial *p* with oil of vitriol, and pour it into the ſame veſſel A, along with the water.

Now let the glaſs funnel *q* (fig. 4,) be put into the mouth of the veſſel A; and filling the

effervescence, is much more regular than otherwiſe. In general it continues to furniſh *fixed air* more than twenty-four hours. When no more air is produced, if I decant out of the veſſel A, all the acid fluid, already ſaturated, and waſh off the thin, white ſediment, I may employ again the remaining granulated marble, by adding to it freſh water, and a new quantity of vitriolic acid; which will then furniſh a further ſupply of *fixed air*: and this may be repeated over again, until all the marble is diſſolved; which will not be very ſoon.

trough

trough *R* (fig. 6,) with the pounded chalk or marble, let it be thrown into it. Take off the funnel *q*, which is uſed only to prevent the chalk from touching the inſide of the mouth of this veſſel: ſince otherwiſe it will ſtick ſo ſtrongly to the neck of the veſſel B, as not to allow the taking it off again without breaking. Then immediately place the two veſſels B and C as they are, over the mouth of the veſſel A; and all the fixed air which is diſengaged from the chalk or marble, by the force of the diluted acid, will paſs up through the valve V into the veſſel B. When this fixed air comes to the top of the veſſel B, it will diſlodge from thence as much water as its bulk: and this water, ſo diſlodged, will go up, by the crooked tube 2, 1, into the veſſel C.

11. Care muſt be taken not to ſhake the veſſel A when the powdered chalk is poured in; for otherwiſe a great and ſudden effervеſcence will enſue, which will, perhaps, expel part of the contents. In ſuch a caſe, it will be neceſſary to open the ſtopple *m*, in order to give vent to the effervеſcence for a moment; otherwiſe the veſſel A may happen to burſt. Perhaps it will be neceſſary to throw away the contents, to waſh the veſſel with water (becauſe the boiling matter will ſtick between the necks of theſe veſſels, and will cement them to-

gether) and to begin the operation afreſh. But if the powdered chalk is thrown in, without any conſiderable ſhake of the machine, there will be but a ſmall effervescence at the beginning. When this operates well, the veſſel *C* will ſoon be filled with water, and the veſſel *B* half filled with air; which when done will be eaſily perceived, by the air going up in large bubbles by the crooked tube 1, 2; this will take place in about two or three minutes.

12. As ſoon as this is obſerved, take off the two veſſels B and C, together as they are, from A; put them on the ſtand *K* (fig. 3,) and, taking the other two, G H, from the ſtand F, put them over the veſſel A. Whilſt the operation is going on in the veſſels G H, hold, with the right hand, the veſſels B C, which are now on the ſtand *K*, by the neck *z z*, inclining them a little ſideways, and ſhake them very briſkly, ſo that the water within B be very much agitated, preſenting many freſh ſurfaces in contact with the fixed air, great part of which will be abſorbed into the water; as it will appear by the end of the crooked tube being conſiderably under the ſurface of the water in the veſſel B.

13. It will ſuffice to ſhake the water in this manner during two or three minutes; which done,

done, looſen the upper veſſel C, ſo that the remaining water may fall into the veſſel B, and the unabſorbed air may go out: then taking off theſe veſſels from the ſtand K, put them, joined together as they are, on the ſtand F (*c*). By this time the veſſel G will be half filled with fixed air, and the upper veſſel H will be filled with the water, thrown up by it. Take then theſe veſſels to the ſtand K, and replace the others B C, on the mouth of the veſſel A; in order to be half filled again with fixed air, whilſt the water in the veſſels G H is briſkly ſhaked in the ſame manner as the others have been.

14. Whenever the efferveſcence nearly ceaſes in the veſſel A, it will be revived again by giving it a gentle ſhake, ſo that ſome part of the powdered chalk which is in a heap at the bottom of A, may be mixed with the diluted vitriolic acid, and diſengage more fixed air. However, when it happens that the whole is exhauſted, and no more air ruſhes up to the middle veſſel from the lower one, either more powdered chalk muſt be put in, or more oil of vitriol; or at laſt more water, if neither of

(*c*) By this method, even the ſimple glaſs machines above mentioned No. 3, already deſcribed No. 5 and 6, may be worked ſo as to have the water fully impregnated in a few minutes, though with leſs advantage.

the two firſt produced the deſired effect. Theſe additions may be performed by letting them in, through the mouth of the veſſel A, whilſt the upper veſſels are changing. In this caſe uſe muſt always be made of the funnel *q*, in order to avoid the ſticking of the junctures above mentioned (*d*.).

15. When this operation has been repeated three or at moſt four times alternately, with each ſet of veſſels, by throwing out the remaining air which does not incorporate with the water, and putting in a freſh quantity of fixed air, the water contained in the two veſſels B and G, will be fully ſaturated; and will be much more pleaſant to taſte than the natural Pyrmont or Seltzer's waters, which, beſides their fixed air (hardly the half of what this artificial water may abſorb) contain ſome diſagreeable ſaline taſte, which, it is known, does not contribute at all to their medicinal virtues; but, on the contrary, it may be hurtful in ſome complicated caſes.

(*d*) Theſe directions muſt be reſpectively applied to the ſimple glaſs machines, mentioned No. 3, and deſcribed No. 5 and 6, when they are employed. If theſe veſſels be ſuffered to ſtand ſix or ſeven hours, the water will be ſufficiently impregnated without agitation; provided the ſupply of fixed air be copious.

16. Theſe

16. Theſe artificial waters will remain as limpid and as tranſparent as before, although there has been abſorbed above as much air as their own bulk. The whole proceſs will hardly take above a quarter of an hour, by this method; and the quantity will be double of that which could be made in the ſimple glaſs-machine. The water may be taken out by the opening *l* or *n*, to be drank immediately; if not, it will be better to let it remain in the machine, where it has no communication with the external air: otherwiſe, the fixed air goes off by degrees, and it becomes vapid and flat; as it happens alſo to the natural acidulous waters. This artificial water may be kept a long time, in bottles well ſtopped, placed with their mouths downwards.

17. In general they are ſo ſimilar to the natural acidulous waters, that they may be even made to ſparkle like Champaign wine. Mr. Warltire has actually brought theſe waters to this ſtate, by keeping the fixed air compreſſed upon the ſurface of the water in the middle veſſel; as appears by his letter printed in the Appendix to your third volume of *Experiments and Obſervations on Air*, page 366. The ſame end will be obtained, if, inſtead of the ſtopples *w* and *i*, uſe is made of the ſolid one repreſented (fig. 7,) which has a kind of baſon

at the top, in order to hold ſome additional weight. This ſtopple muſt be of a conical figure, and very looſe; but ſo well ground and ſmooth in its contact, as to be air-tight by its preſſure, which may be increaſed by ſome additional weights in its baſon. If the veſſels are ſtout enough, there is no danger of their burſting in the operation.

18. Theſe waters may alſo be rendered ferruginous (or chalybeate) very eaſily, by putting, in the middle veſſel, two or three balls of fine iron-binding wire: otherwiſe two or three ounces of ſmall iron nails may be put in for the ſame purpoſe; becauſe they will diſſolve iron as much as to be ſaturated with it in a few hours, according to the experiment of Mr. Lane. According to Sir John Pringle, there may be added from eight to ten drops of *tinctura martis cum ſpiritu ſalis*, in order to reſemble more nearly the genuine Pyrmont water.

19. No doubt theſe waters may be advantageouſly employed in many medical purpoſes; not only by diſſolving in them the very ſalts which are found to be contained in many natural ſprings, renowned for their different virtues, but even they may be applied as a vehicle to many draughts and internal medicines, which

which will be leſs nauſeous to the patients, and perhaps more agreeable to the ſtomach, giving to it a tonical ſtrength.

20. I ſhall conclude this ſubject by obſerving with you, that fixed air may be given to wine, beer, cyder, and to almoſt any liquor whatſoever. Even when beer is become flat, or dead as it is called, it may be revived by employing the ſame method: but the delicate, though briſk, and agreeable flavour, or acidulous taſte, communicated by the fixed air, and which is ſo manifeſt in water, will hardly be perceived in wine or other liquors which have much taſte of their own. I ſhall now proceed to the ſecond object of this letter.

ON EUDIOMETERS.

21. The happy diſcovery you have made for the general benefit to mankind, and perhaps of almoſt the whole animal creation of this globe, by finding that *nitrous air is a true teſt of the purity of reſpirable air*, which is abſolutely neceſſary to life, and without which it is preſently extinct, gives a moſt ſtriking inſtance of the blameable ſlowneſs of mankind to pay a proper attention to thoſe objects, the importance of which is infinitely ſuperior to

that of the numerous trifling novelties which ſo often ſpread with prodigious rapidity through remote provinces, and even to the moſt diſtant countries of the earth. Since the beginning of the year 1772, in which you announced this moſt intereſting and valuable diſcovery, in the 62d vol. of the *Philoſophical Tranſactions*, no more than three or four philoſophers that I know of, have given any conſiderable degree of attention to ſo important a ſubject.

22. The Abbé Fontana and the Chevalier Landriani, both of Italy, and already known to the public by their ſeveral valuable productions, were the firſt, as it ſeems, who availed themſelves of this diſcovery (*e*). Both propoſed

(*e*) Mr. Volta, Profeſſor of Natural Philoſophy at Como in Italy, has made a diſcovery, mentioned No. V. of the Appendix to your third volume *On different Kinds of Air*, which ſeems cloſely connected with the preſent ſubject. He diſcovered that *inflammable air* is contained in the mud of almoſt all lakes, marſhes, and wet grounds of Italy. He publiſhed different letters on this ſubject, of which he was ſo kind as to ſend me a printed copy, after part of this letter was printed. The experiments you have made afterwards with me at Calne on this matter, ſhow that this air is leſs inflammable than what proceeds from the ſolution of metals, with vitriolic acid; it burns with a lambent flame, like the air produced by heat from charcoal. This diſcovery of profeſſor Volta accounts very well

propoſed to the public one of the moſt uſeful kinds of inſtruments that we can boaſt of among the numberleſs ones already employed in philoſophical reſearches and experiments. They gave to theſe inſtruments different forms, as appears by the printed deſcriptions that each of them has ſeparately publiſhed: and the Chevalier Landriani has tranſmitted to England, as a preſent to you, the very inſtrument he had made uſe of, to eſtimate the reſpective ſalubrity of the air in different parts of Italy, as mentioned page 23 of the Preface to your third volume *On different Kinds of Air*. This

well for the unhealthy habitations ſuch marſhy grounds generally afford to the human ſpecies: and ſhows the neceſſity of examining, with care, by means of the Eudiometer, what places are fit for being inhabited. This is a new and a very intereſting requiſite, never to be overlooked, before any building is erected, or the place for any country ſeat is fixed upon. Such grounds or places whoſe atmoſphere is loaded with phlogiſtic miaſma, are the moſt dangerous to animal life: becauſe the air of ſuch an atmoſphere cannot be a good conductor or diſcharger of the ſuperabundant phlogiſton, of which the animal œconomy requires to be unloaded: this being the aim intended by Nature in the function of reſpiration, as you have at laſt diſcovered, and incontrovertibly demonſtrated, by the moſt deciſive experiments, to be the caſe; after ſo many ineffectual attempts of the greateſt philoſophers of all ages. This appears by ſection V, page 55 and following, of your third volume *On different Kinds of Air*. London Edit. 1777, and by *Phil. Tranſact.* vol. 66, p. 216.

Eudiometer is ſmaller than that deſcribed by him, and publiſhed in the 6th volume of Roſier's Journal for the year 1775, though nearly of the ſame form. It conſiſts of a glaſs tube, ground to a cylindrical veſſel, with two glaſs cocks, and a ſmall baſon, all fitted in a wooden frame. Quickſilver is there uſed inſtead of water; and that part of it which replaces the bulk loſt by the diminution of the two mixed airs, is conducted either through a kind of glaſs ſiphon, or through the capillary holes of a glaſs funnel: ſo that by its fall, the whole mixture of the two kinds of air is more readily made.

23. Dr. Falconer of Bath ſent, ſome time ago, to the Royal Society of London, a glaſs tube, neatly divided; by means of which one may be enabled to know the quantity of diminution produced in a certain bulk of the mixture of *nitrous air* with another air, in order to judge of its ſalubrity, which you have ſhewn to be in proportion to the *diminution ſuffered in the ſum of their original bulk, after they are mixed together*. This method is the neareſt to your original one, or, rather, is the very ſame you have uſed in the purſuit of this diſcovery; as appears by your printed work on this ſubject: and I think it to be the readieſt of all, whenever no great nicety is required in obſervations

of this kind. There are, however, ſo many circumſtances neceſſary in a good inſtrument for fully anſwering ſo great an object to its utmoſt extent, that I ſhould be deterred from offering to the public what I have as yet done on this ſubject, was I not aware, that ſome advantages always accrue to public good, by any new ſteps towards perfection, how diſtant ſoever we may ſtill happen to be from its compleat attainment.

DESCRIPTION OF THE FIRST NEW EUDIOMETER.

24. Of the three Eudiometers I have contrived, which are repreſented fig. 8, 15 and 16 in the annexed plate, I think the laſt is the eaſieſt in its application, and the moſt exact in its reſults. It is repreſented alſo (fig. 12, 14, and 17) in different poſitions, for the better underſtanding of its application: and it conſiſts of the following parts: *viz.* a glaſs tube *m n e d* fig. 16, about twelve or fifteen inches long, and of an equal diameter, with a ground glaſs ſtopple, *m*: a veſſel, *c*, the neck of which is ground air-tight to the lower end *d* of the tube: and two equal phials *a* and *b*, whoſe necks are alſo ground air-tight to the reſpective mouths of the veſſel *c*. Both theſe phials

contain nearly as much as the whole tube *m n e d*. There is, moreover, a ſliding braſs ring, marked *z*, which ſlides in the tube *n d*, and may be made tight at pleaſure by a finger-ſcrew: and, laſtly, a ruler, either of braſs or of wood, repreſented fig. 11, which is divided into equal parts, and indicates the contents of both the phials *a* and *b*, when thrown into the tube, by the number of parts which is engraved or ſtamped about the middle of it. The two bent pieces of braſs *z t* ſerve to hold it eaſily by the ſide of the tube *n d* fig. 14 and 17, keeping it cloſe to its neck *n* by the notch *i*.

25. Experiments with theſe Eudiometers, which are eaſily conſtructed, may be made either with water or with quickſilver; with this difference, that when the laſt is made uſe of, the Eudiometers (particularly the third, repreſented fig. 8, which ſeems the fiteſt for being uſed with quickſilver) will be more convenient if made of a ſtill ſmaller ſize. Mercury, however, is a fluid that, I think, never ought to be uſed preferably to water, in the inſide of Eudiometers; becauſe it ſuffers a ſenſible action from the contact with nitrous air, as yourſelf have obſerved: and this muſt have an influence on the reſult of the experiments. Water, on the contrary, ſeems leſs liable to miſtakes, although it imbibes ſome part of the *ni-*

trous

trous air. In fact this effect only takes place in a long time, or with much agitation: and, after duly weighing the queſtion on both ſides, I ſhould think water may be generally uſed, without the fear of any ſenſible error. The weight and the dearneſs of quickſilver, are, likewiſe, two other conſiderations to give the preference to water in theſe experiments.

THE PROCESS.

26. In the firſt place there muſt be either a trough, as repreſented fig. 17, or at leaſt a common tub, nearly filled up with water, unleſs the tall glaſs receiver, of which I ſhall ſpeak No. 34, be at hand. I take out the ſtopple *m* (fig. 16,) fill the Eudiometer entirely with water, keeping it in the poſition repreſented fig. 16 and 17. I then ſhut it with the ſtopple *m*, without leaving any bubble of air in the inſide; and put the lower part *c* under the ſurface of the water in the tub (fig. 17,) in an erect poſition as it is therein ſeen. I take the phial *a*, filled with water; and, keeping its mouth downwards under the ſurface of the water, I fill it with that air, the ſalubrity of which I want to aſcertain *(f)*. This is done either

(f) The caſe I am ſpeaking of, is when I have a bottle of

either by putting the phial *a* on the ſhelf *n. o* of the tub fig. 17, and throwing the air into the glaſs funnel *t*, which is there cemented to the ſhelf; or by holding in the left hand the ſame phial *a*, together with the glaſs funnel *B* (which is repreſented fig. 18, and has no pipe at all) applied to the mouth of the phial, whilſt I pour the air with my right hand into it. But leſt the heat of my hand ſhould produce any conſiderable expanſion in this air, I generally uſe, in hot weather, the wooden tongs, repreſented fig. 21, with two bent wires *x x*,

of air, which has been taken at any diſtant place, and ſent for trial. If a glaſs bottle, with a ground glaſs ſtopple, is filled with water or with mercury, and emptied in the place whoſe atmoſpherical air is intended for being examined, it will, of courſe, be filled with that air: and, being cloſely ſhut with the glaſs ſtopple, may be carried to any diſtant place for trial. By this means the atmoſpherical air of any part of a country may be ſent to any diſtant one, in order to aſcertain its comparative ſalubrity: and many uſeful inquiries and diſcoveries may be made hereafter on this ſubject, with great eaſe, and at very ſmall expence.

But if I only want to try the air of the room, where I have the Eudiometer, I then only pour out of the phial *a* the water it contains. I find that, however, after ſome trials with *nitrous air*, the atmoſphere about me is loaded with phlogiſtic miaſma: and for that reaſon I always empty the phial *a* out of the window of the room, in order to have nearly the ſame kind of air in all the experiments.

in

in order to hold the glaſs funnel z cloſe to the mouth of the phials; unleſs they are made with a ſolid lump at their bottoms, as repreſented in the plate. *See note* (*g*).

27. The phial *a* being filled with that air, the ſalubrity of which I am to examine, I put it into the mouth of the veſſel *c*, making it rather tight,

(*g*) There are ſome niceties to be obſerved in order to fill up, exactly, any phial intended to ſerve as a meaſure of air, of which I muſt give an account in this place. The eaſieſt method to ſucceed is the following: Let a glaſs funnel *t* (fig. 17) be cemented under the hole *n* of the ſhelf *n o* in the trough. In this caſe I hold the phial *a* filled with water, with its mouth downwards over the hole *n* of the funnel *t*: I throw the air into the funnel: and, when the phial is filled with air, I take it ſideways, rubbing its mouth along the ſurface of the ſhelf, ſo that the redundant air, adhering to the mouth of the phial, be got off: and I put it into the mouth of the Eudiometer belonging to it. But as the heat of the hand muſt expand the air contained in the phial, which of courſe will then contain leſs air than its real meaſure in the temperature of the ſurrounding water, I handle the phial with a kind of pliers or tongs of wood, repreſented fig. 21, till the neck enters into the proper place of the veſſel *c*, where I ſecure it with the other hand: and, laying aſide the wooden tongs, I make it properly tight. But if the phials have a ſolid knob at their bottoms, as repreſented in the plate, it will then be enough to handle them by it only: ſince the heat of the hand can not be communicated in ſo ſhort time to the air in the inſide.

If

tight, which muſt be done with ſome care; for if the phials *a* and *b* are not tight enough to the reſpective mouths of the veſſel *c*, they will ſlip out, when turned downwards, and of courſe will be broken: and, if they are too tight, the veſſel *c* will be eaſily cracked, and become unfit for uſe. The better to avoid theſe accidents, and to judge of the proper degree of tightneſs, let the necks of the phials *a b*, and of the veſſel *c*, as well as the glaſs ſtopple *m*, be always rubbed with tallow, previouſly to every experiment. When I have done with the phial *a*, I take the other phial *b*, filled with water: by the ſame method

If I have not the convenience of a trough, prepared with a ſhelf, and its fixed funnel, as above mentioned, an aſſiſtant holds the funnel under the water in a common tub, whilſt I fill up the phial with air: and I take care to hold the phial in ſuch a manner that the end of the funnel be out of the inſide of the phial at the laſt moment, that the air may ruſh out after it is totally filled: otherwiſe that part of the phial, occupied by the end of the funnel, will not be totally filled with the air.

Even without any aſſiſtant, but with a little care, a perſon may hold both the phial and the funnel in the left hand, whilſt he throws the air into it with the other hand; as I have myſelf frequently done in experiments of this kind: and when I make uſe of the wooden tongs, I add to it the two bent pieces of wire *x x* (fig. 21) by means of which the funnel is kept cloſe to the mouth of the phial.

I throw

I throw into it as much *nitrous air* as to be perfectly filled up with it: and I then replace this phial *b* in the other mouth of the veſſel *c* (*b*).

28. I take afterwards the Eudiometer with my left hand, holding it near the lower part *d*,

(*b*) No pains or trouble ought to be ſpared, in order to obtain, at any time, a *nitrous air* perfectly alike in its contractive power, when mixed with common air.

In order to come the neareſt to this, I take a phial *D* (fig. 19,) like thoſe you have deſcribed in the ſecond volume of your work *On different Kinds of Air:* to the mouth of which is ground air-tight the crooked tube *n z* in the ſhape of an S. I fill the half of this phial with thin braſs wire, the thickneſs of which is equal to $\frac{1}{40}$ of an Engliſh inch, nicely cut by a pin-maker to this length. I fill the three quarters of the phial with common water; and the remainder with ſtrong *nitrous acid*, which I have always taken of the beſt ſort, at the Apothecary's Hall in London. I put the crooked tube *n z* to the phial: and, as ſoon as the efferveſcence cauſes the liquor to riſe to the end *z* of the tube, I paſs it under water into the mouth of the bottle *E* (fig. 20,) which is filled with water, and inverted with its mouth downwards upon the hole of the ſhelf *n o*, which appears covered with water within the trough, or pan, (fig. 17).

This figure repreſents the moſt commodious ſhape a trough muſt have for any experiments on different kinds of air. It is made with ſtrait boards of elm-wood *one inch* thick. The inſide dimenſions are 25 inches long, $13\frac{1}{2}$ wide, and 11 deep, Engliſh meaſure. The two end boards, *c d* and *e f*, are fitted into a groove cut in the other

d, over the ſurface of the water in the trough, to avoid breaking any of the phials, if it chances

three boards; this is daubed with thick white painting, as a cement, to keep well the water in: and the whole is faſtened with nails from the outſide. The ſhelf *w a n o* is eight inches wide, and two inches thick. It has three holes of three tenths of an inch diameter, with as many ſeparate cavities underneath, ſo as to ſerve like ſo many funnels. The figure, however, repreſents a glaſs funnel *t* cemented to the middle hole *n*: which is equally convenient. This ſhelf is ſupported by four metallic hooks *V w z z*, which may be raiſed or lowered at pleaſure, by the wooden wedges there repreſented.

When the bottle *F* is entirely filled by the *nitrous air*, I ſhut it up with its ſtopple *x* (fig. 20,) which I paſs under the ſurface of the water, to avoid any communication with the external air: and I puſh this bottle under the ſhelf, where I let it remain for a quarter of an hour, to acquire the ſame temperature of the ſurrounding water: and the ſame I always obſerve with the bottle, containing that atmoſpherical air which I deſire to try, before I put it into the phial *b*.

I muſt acknowledge, however, that, notwithſtanding theſe precautions, I cannot ſay that all the reſults of my experiments, even when made upon the ſame atmoſpherical air, have as yet agreed ſo exactly as I flattered myſelf they would. Perhaps there was ſome difference in the ſtrength of the *nitrous air*, the denſity of which I thought might eaſily be brought to a ſettled ſtandard, to be determined by means of a glaſs hydrometer. Perhaps there was ſome other little variety in the circumſtances of the experiments, the influence of which I was not aware of. But let it be as it may: I very willingly leave this problem to be reſolved

ces to fall; and, with my right hand, I turn the veſſel *c* upwards, ſo that the two phials may be downwards, as repreſented fig. 14. By this operation the two kinds of air come up to

ſolved by abler chemiſts than I can pretend to be: and I heartily wiſh they may ſucceed better than I have done: for, without being aſſured of getting every where a certain *ſtandard nitrous air*, by which the ſame atmoſpherical air be equally affected, we cannot draw with certainty any general deciſive concluſions, from Eudiometrical experiments made in diſtant times or places.

Before I leave this ſubject, I cannot help mentioning two ſtriking circumſtances relating to *nitrous air*. The firſt is the great quantity produced by the action of *nitrous acid* on many metals; which may ſtill be carried to a greater extent, if helped by bringing the flame of a candle to the phial, which contains the ſolution, when it ſeems to be nearly done with. The ſecond is the antiſeptic power of *nitrous air* to preſerve animal matters from corruption. A beef-ſtake, almoſt entirely putrid, and with an inſupportable ſtench, being put into a jar of *nitrous air*, in leſs than two days was perfectly reſtored, and very eatable when dreſſed. A pigeon was very well preſerved above ſix weeks by the ſame treatment; and, when roaſted, was found ſo good as to be eat without any diſlike. Two other pigeons were kept in it full ſix months without corruption: they were ſtill very firm and of a good colour; but the fleſh had loſt all its flavour, and was far from being eatable when dreſſed. But the *nitrous air* for theſe œconomical purpoſes, which may be of a great reſource at ſea, as well as at home, muſt be made out of *nitrous acid* with iron, or other metal leſs exceptionable than braſs or copper, the effluvia of which are pernicious to animals.

x, from the phials *a b*; and there they mix together in the beſt poſſible manner; the particles of each having a large room to come into contact with each other; ſince the foremoſt ones do not detain thoſe which are behind, as it happens when this mixture is made in a narrow veſſel. This being done, I immediately dip the Eudiometer in the water of the trough (fig. 17,) leaving the mouth of the inſtrument above its ſurface; ſo that no more water may enter into it than what it had at firſt. I then obſerve with attention the moment when the mixture *x* (fig. 14,) of the two kinds of air comes to its greateſt diminution, after which its bulk will begin to increaſe again. In order to catch this moment with certainty, I ſlide down the braſs ring *z* of the inſtrument, as the ſurface of the water in the tube falls. This point of the greateſt diminution will be eaſily perceived, by obſerving when that inſide ſurface is ſtationary: which will happen in a few minutes, if the *nitrous air* has a proper ſtrength *(i)*.

29. As

(*i*) The bulk of the mixed air will decreaſe to a certain degree, within a few minutes, according to the ſtrength of *nitrous air*. Afterwards it will begin to expand again: but this it will do to a very ſhort limit, much below its former bulk. This is a phenomenon which, I think, I have obſerved the firſt on theſe experiments; having

29. As ſoon as the diminution of the two kinds of air appears to be ſtationary, I fill up the whole tube of the Eudiometer with water: I ſhut it up with the ſtopple *m*; and incline the top of the inſtrument forwards, till the air comes from *x* (fig. 14,) up to the top *n* of the tube. I then keep the lower part of the inſtrument dipped in the water; take off the glaſs veſſel *c* with the two phials *a b*, and riſe or lower the tube of the Eudiometer, ſo as to ſee the ſurface of the water, in the inſide, even with that in the outſide; which I mark by ſliding to it the braſs ring *z*. Otherwiſe I apply the ruler (fig. 11, without making any uſe now of the braſs ring) to the ſide of the Eudiometer, whilſt it is immerſed in the water of the trough: and there I ſee the true dimenſion of the remaining bulk of the two kinds of air, already diminiſhed. Perhaps the beſt method for this obſervation would be to allow time enough that the mixed air may take its ſettled bulk: but this requires ſometimes twenty-four hours time. I leave, however, the choice of theſe two methods to the obſerv-

ing made a very great number of them with nice Eudiometers, of the kind I am now deſcribing. It certainly deſerves the attention of Philoſophers: and, although I have communicated it to ſome of my acquaintance, none have as yet, in my humble opinion, given a ſatisfactory ſolution of this phenomenon.

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er, who may uſe both if he pleaſes, provided he keeps diſtinctly the reſult of each method in his account of the experiment.

30. The number marked about the middle of this ruler (fig. 11,) as for inſtance, * *=96, means that the contents of both phials *a* and *b* are equal to ninety-ſix diviſions of the ruler, when put into the tube of that Eudiometer: that is to ſay, they are equal to a ſolid cylinder, as thick as the inſide of the glaſs tube, and whoſe length is ninety-ſix diviſions of the ruler, which has been divided into tenths of an Engliſh inch.

31. Now if, for inſtance, this remaining bulk of mixed air correſponds to the 56th diviſion of the ruler, it ſhews that, out of 96 parts, only 40 (=96—56) have been loſt or contracted: and, in this caſe, the wholſomeneſs of that air, which I call A, will be $\frac{40}{96}$. If another equal quantity of different air, which I ſhall call *B*, had alſo been tried by the ſame Eudiometer, and its reſiduum was equal to 60 parts of the ſame ruler, the reſpective ſalubrity of the air *B* will then be to that of the air *A*, as 36 (=96—60) to 40.

32. But if the air *B* had been tried by another Eudiometer, whoſe proportional dimenſi-

ons, marked about the middle of its ruler, were * * = 108, then the reſpective ſalubrity of theſe two kinds of air *A* and *B*, would be in the compound ratio of $\frac{36}{108}$ to $\frac{40}{96}$ $= \frac{36\times96 \text{ to } 40\times108}{108\times96} = 3456$ to $4320 = 54$ to $67,5$: that is to ſay, the wholſomeneſs of the air *B* would be to that of the air *A*, as 54 to $67\frac{1}{2}$ (*k*).

33. Nearly the ſame reſults would be found, if the ruler (fig. 11,) was applied to the ſide of the

(*k*) It is ſuppoſed that the inſide of the tube is of an uniform diameter ; but it often happens, that there are ſome varieties in different parts of its whole length. When they are not very conſiderable, we may neglect their influence in the reſult of theſe Eudiometrical experiments ; but, when the contrary happens, it will be very eaſy to make a proper allowance for them in the calculation. It is for this reaſon that I have always ordered that the contents of one ſingle phial be marked alſo upon the ſcale of each Eudiometer, as well as the contents of both phials ; for inſtance as in this manner :

* * = 96
* = 47

which means, firſt, that the contents of both phials *a* and *b* are equal to a cylinder, whoſe diameter is the ſame as that of the inſide bore of the tube *n d* (fig. 16,) and whoſe height is equal to 96 equal diviſions of the ruler : ſecondly, that the contents of a ſingle phial are equal to 47 diviſions in the upper part of the ſame tube *m n d* ; and of

the Eudiometer, as ſoon as the incloſed mixture of air came to its utmoſt diminution, as mentioned No. 28: becauſe as much water muſt fall in the tube *n d*, as correſponds to the diminution ſuffered by the two mixed airs in *x*. But there are ſome varieties, which ariſe from the different preſſure of the column of water, which preſſes more or leſs upon the air at *x* (fig. 14,) as it is longer or ſhorter: and theſe varieties ought not to be overlooked in nice experiments: they are avoided by the proceſs already deſcribed, No. 29; and may otherwiſe be prevented by the method of which I will ſpeak at the end of No. 39.

34. Whenever I have at hand a tall glaſs receiver, like that repreſented fig. 14, the whole proceſs is then more eaſily performed: for in this caſe I dip the Eudiometer, inverted as it appears fig. 12, into the water contained in the veſſel *V S q l*: I then put the two kinds of air into the phials *a* and *b* as above ſaid, No. 26 and 27: I turn the inſtrument upright, as repreſented fig. 14; and finiſh the proceſs, as I have already deſcribed.

of courſe, to 49 diviſions (=96—47) of its lower part. By this difference it appears that the tube of ſuch Eudiometer is wider in the top than at the bottom, by $\frac{2}{96}$ of the whole.

35. I muſt, however, warn the operator that, unleſs every trial, and even almoſt every part of the proceſs, be made in the ſame temperature; or, at leaſt, unleſs the varieties ariſing from this cauſe be accounted for no reliance can be had on the reſult of ſuch experiments: it being well known, that air is apt to increaſe or diminiſh very conſiderably in its bulk, by the influence of heat and cold. It is for this reaſon that I conſtantly keep a good thermometer *K*, which hangs by the wire *y r*, and is immerſed in the water of the glaſs veſſel fig. 14, or in the trough fig. 17, whenever I make any of theſe experiments. For the ſame reaſon I take care to leave the Eudiometer and the veſſels of air, immerſed in water time enough, as above mentioned, to get the ſame temperature: and I make uſe of the wooden tongs mentioned in note (*g*), whenever I handle the phials *a b* filled with air, chiefly if they have not the ſolid lump at their bottoms, as repreſented in the plate; unleſs I feel the heat of my hands to be the ſame as that of the water, in the trough, I make uſe of.

DESCRIPTION OF THE SECOND NEW EUDIOMETER.

36. The Eudiometer, repreſented fig. 15, conſiſts of a glaſs tube *t c*, two or three feet

long, and of an uniform diameter: the end *c* is bent forwards; and the other end *t* is wide open, as a funnel, unleſs a ſeparate one is made uſe of: this tube is faſtened, by two loops, to the braſs ſcale *c w t V*. There is a glaſs phial *n*, the neck *V* of which is ground air-tight to the end *t* of the tube; and contains only half of the whole inſide capacity of the divided tube *c t*. It has, at the other end *c*, a large round phial *a b c*, containing three or four times the bulk of the phial *n*: its neck is alſo ground air-tight to the mouth *c* of the tube. The braſs ſcale *c w t V* is divided into 128 equal parts: this being a number that can be divided to unity in a ſubduplicate ratio without fraction, by continual biſections; on which account it is one of the numbers the late famous Mr. Bird had adopted for his dividing mathematical inſtruments with the utmoſt accuracy. Theſe numbers are ſet out in the ſcale from *t* towards *c*. The contents or capacity of the tube till the number 128 is the double of the capacity of the phial *n*. Beſides this there is a tin veſſel *x s d t r o* (fig. 15*), which may ſerve as a packing caſe for the whole inſtrument, and its neceſſary appendages; and alſo as a trough, when experiments are made; it being then filled with water. Both the glaſs tube repreſented fig. 22, and the glaſs ſtopple *m* (fig. 15*), belong to this

this Eudiometer; and both are fitted in, air-tight, to its mouth *V*.

THE PROCESS.

37. Let the inſtrument be immerſed under the water *z z* of the tin veſſel fig. 15*: and let the phial *n*, filled with water, be put in the inſide ſocket *e e d* of the tin veſſel. Let it be filled with *nitrous air*, as above directed at the end of No. 27: and let this quantity of air be thrown into the phial *a b c* (as directed No. 26 and No. 27), which I fix a little tight to the mouth *c* of the Eudiometer. I afterwards fill the ſame phial *n* with the air I want to try: and, raiſing the end *c* of the inſtrument, I put it into its mouth *V*: when this is done, I ſet the inſtrument upright, as repreſented fig. 15, hanging it on the hook *w*; and, as ſoon as this laſt air goes up to the phial *a b c*, I take off the phial *n*, that the diminution of the two mixed airs may be ſupplied from the water in the tin veſſel; which muſt be the caſe, as the mouth *V* of the Eudiometer is then under the ſurface of the water.

38. I then put to the lower end *V* of the Eudiometer, the bent tube fig. 22, to which is fitted the braſs ring *K*, and is filled with

water. It is by obſerving the ſurface of the water in this ſmall tube (which then forms a true ſiphon with the tube of the inſtrument) and by means of the braſs ring *K*, that I can diſtinguiſh the ſtationary ſtate of the diminiſhing bulk of the two mixed airs, above mentioned at the end of No. 28 : which being perceived, I take off the ſmall tube *g h* from the Eudiometer, and lay down, for ſome minutes, the whole inſtrument, in an horizontal poſition, under the water of the tin veſſel : I ſhut up the mouth *V* with the glaſs ſtopple *m*; and, reverſing the inſtrument, I hang it up by the end *V*, on the hook *w*. By this poſition the whole diminiſhed air of the veſſel *a b c* goes up to the top, where its real bulk is ſhewn by the number of the ſcale, facing the inſide ſurface of water. This number being deducted from 128, gives the comparative wholſomeneſs of the air already tried, without any further calculation.

39. But this proceſs will be ſtill eaſier, when the laſt diminution of the two mixed kinds of air, mentioned No. 29, is only required in the obſervation : becauſe no uſe will be then made of the ſyphon (fig. 22). In ſuch a caſe the inſtrument is left hanging on the hook *w* for 48 hours : after which it is laid down under the water of the trough (fig. 15*), in an horizontal

tal poſition, for 8 or 12 minutes, in order to acquire the ſame temperature of the water: the mouth *V* is then ſhut up with the ſtopple *m*; the inſtrument is hung by the end *V* in a contrary poſition, and the laſt real bulk of the good mixed air will be then ſhown by the number of the braſs ſcale anſwering to the inſide ſurface of the water. This number being ſubtracted from 128, will give the comparative ſalubrity of the air employed in the trial, without any further calculation. I need not ſay that all the circumſtances already mentioned for the better obtaining exact reſults in theſe experiments, are to be carefully obſerved, when this ſecond, or the third Eudiometers are uſed: but chiefly that circumſtance, mentioned No. 35, ought never to be omitted. The thermometer is to be kept dipped in the water of the tin veſſel; and the Eudiometer muſt be kept there immerſed ſome minutes, as I have ſaid juſt now, before it is raiſed for the laſt time, to read off the quantity of the total diminution of the mixed air. As to the other circumſtance, mentioned No. 33, it has been rendered unneceſſary by laying this Eudiometer in an horizontal poſition before the glaſs ſtopple was put in. The ſame method muſt be applied to the third new Eudiometer I am going to deſcribe; and even the firſt Eudiometer, already deſcribed, may be treated in the ſame manner: for if it be

laid

laid down in an horizontal poſition under the water in the tub, before it be ſhut up with the ſtopple, as directed No. 29, there will be no variation produced by the expanſion of the air in the inſide: becauſe the proper quantity of water is then ſhut up within the glaſs veſſel *c* of the inſtrument: ſo that raiſing it up, as it is, together with the veſſel *c*, and its phials *a b* (fig. 14), the weight of the column of water will preſs totally upon them, without expanding the incloſed air, or cauſing any variation beyond the trifling one which may proceed from the natural elaſticity of the ſides of the glaſs tube and veſſels.

40. I muſt, however, acknowledge that, the long way through which the air paſſes, in going at firſt to the large phial *a b c* in this ſecond Eudiometer, muſt leave ſome doubt whether it has not then ſuffered ſome ſenſible change in its quality, before it is mixed with the *nitrous air*; ſince, as you have obſerved, the air that has been long agitated in water, changes for the better from its bad qualities: and this objection muſt be ſtill greater in the uſe of the third Eudiometer. It is on this account that I have mentioned the firſt Eudiometer, as the leaſt exceptionable of all that we know till the preſent; and perhaps the nature of the thing is not capable of a further perfection.

Indeed

Indeed that inſtrument, I mean my firſt Eudiometer, has not only the advantage of offering a very ſmall way through the water to the two kinds of air, on their going to mix at *x* in the veſſel *c* (fig. 14), but they are kept ſeparated till that moment, in the two reſpective phials *a* and *b*, without any other contact with the water, but only in the narrow diameter of the necks of theſe phials.

DESCRIPTION OF THE THIRD NEW EUDIOMETER.

41. This third Eudiometer is the neareſt to your original one: and, was it not for the conſideration I have mentioned in the preceding number (which, perhaps, will not weigh too much with ſome philoſophers) and few other circumſtances which are obvious, I ſhould not doubt to pronounce this third inſtrument to be the beſt of all the three, as I have advanced in my laſt letter to you of the 30th of November laſt. This, however, I gladly ſubmit to your ſuperior judgment.

42. This third Eudiometer conſiſts of a ſtrait glaſs tube *e n* (fig. 8), of an uniform diameter, about two or three feet long, with a large ball *s*, and a glaſs ſtopple *m*, fitted air-tight to the

the mouth *n*, which ought to be wide open, as a funnel, unleſs a ſeparate one is made uſe of. There is alſo a ſmall ſiphon (fig. 23) with a braſs ring *x*: a ſmall phial *z* (fig. 9), the contents of which may be received in the third part of the ball *s*: and, when put into the glaſs tube *n s*, muſt take there no more than the half of its length. Laſtly, this inſtrument has a ruler (fig. 13), which is divided and ſtamped like that other already deſcribed at the end of No. 24; and a glaſs funnel, which is ground to the mouth *n* of the inſtrument, when this is not wide open, as already ſaid.

THE PROCESS.

43. The uſe of this inſtrument is eaſily underſtood by what I have already ſaid of the two preceding ones.

Firſt, it is filled with water, and ſet in a vertical poſition, with the mouth *n* under the ſurface of the water in a tub, or in a trough, (fig. 17).

Secondly, the phial *z* (fig. 9) is filled, as above, with *nitrous air*; and thrown into the tube by means of the glaſs funnel *y* (fig. 10), which is ground to the mouth *n* of the Eudio-

meter; unleſs it be wide enough not to be in need of any funnel.

Thirdly, the ſame phial *z* is again filled with the air to be tried; and thrown into the ſame.

Fourthly, the ſiphon (fig. 23) is added immediately to the mouth *n* of the Eudiometer, under the ſurface of the water; ſome of which is to be poured into it.

Fifthly, the ſtationary moment of the greateſt diminution of the mixed air at *s*, is watched by means of the ring *x*, as mentioned No. 28 and 38.

Sixthly, when that moment arrives, the ſiphon *K l* (fig. 23) is taken off; the Eudiometer is laid for ſome minutes under the water, in an horizontal poſition, or nearly ſo, but in ſuch a manner that no part of the incloſed air may get out; the mouth *n* is ſhut up with the glaſs ſtopple *m*, and the inſtrument is inverted with the mouth *n* upwards.

Laſtly, the ſpace occupied by the reſiduum of the diminiſhed air, is meaſured by applying to its ſide the divided ruler, or ſcale (fig. 13), and the reſult is eſtimated after the manner already explained No. 31 and 32.

44. Whenever I want only to know the laſt diminution of the mixed air, mentioned No. 39, the proceſs then becomes eaſier, as no uſe is made of the ſiphon (fig. 23). The method of conducting the proceſs in ſuch a caſe being reſpectively the ſame as that already deſcribed No. 39, it is unneceſſary to deſcribe it here again. The ſame precautions I have ſpoken of, No. 35 and 39, muſt be obſerved when this Eudiometer is made uſe of, in order to form a true judgment concerning thoſe places, where people will be able to live without danger of hurting their conſtitutions, by breathing and being continually ſurrounded by noxious air; which they have not yet been able to diſtinguiſh from the moſt wholſome, except by a long and too late experience.

45. The Eudiometers already deſcribed are the fiteſt inſtruments for philoſophical experiments, on the bulk of air and other fluids, when mixed together; and even when mixed with ſome ſolid ſubſtances, which can be introduced into the lower veſſel *c* of the firſt of the three Eudiometers. It will be better, however, to have them made purpoſely for ſuch objects, with a tube two or three times longer than I have indicated above. Whenever dephlogiſticated air is to be tried by theſe inſtruments, proper care is to be taken to obſerve the preciſe point of its full ſaturation,

which is that of its greateſt diminution by the addition of *nitrous air*.

46. In order to make this experiment with great accuracy, let a narrow glaſs tube of an uniform diameter (fig. 24), be provided: let one of the two phials *a* or *b* (fig. 16) filled with quickſilver, be thrown into it, and the tube cut exactly to that ſize, ſo as to contain neither more nor leſs. Let its whole length be divided into ſome number of equal parts, by which number the value marked on the ruler (fig. 11), of this Eudiometer, can be divided without any fraction: for inſtance, the number * * = 108, marked in the ruler, means, that the contents of the two phials *a* and *b*, of which I ſpoke No. 32, are equal to a cylinder of 108 diviſions long, as thoſe of the ruler: and, of courſe, it ſhews that a ſingle phial *a* or *b* contains but 54 of theſe parts. In this caſe this tube (fig. 24) may be divided either into 27 parts, each containing two of the ruler; or into 54, into 108, &c.

N. B. If the top of the tube is not very flat in the inſide, it will be more exact to divide the weight of the quickſilver in two parts; to put one of them into the tube; to mark the ſpace occupied by it; to divide the part of it, which was empty, into half the number

intended for this tube, and afterwards to divide the other half into ſimilar equal parts, as the firſt half, carrying them towards the cloſed end.

47. If the dephlogiſticated air is very pure, it will require almoſt double the quantity of *nitrous air* to be completely ſaturated. In order to do this without exceeding the neceſſary quantity, I throw into the tube *n d* (fig. 17) a ſecond meaſure *b* or *a* of *nitrous air*, after I have brought the proceſs to the moment mentioned No. 29: in this caſe the whole volume or bulk of the dephlogiſticated and nitrous air will be 162 [=108+54:] I obſerve where the ſurface of the inſide water in the tube ſtops, and I mark it by the ſliding braſs ring *z*. I then fill up the divided tube (fig. 24) with *nitrous air:* I throw a ſmall quantity into the Eudiometer tube *n d*; and, if it becomes of a rediſh colour, the incloſed air will diminiſh: I then puſh up the ring *z*, and, by this means, I go on throwing in the nitrous air, by little and little, till I ſee that the whole diminiſhes no more; which ſhews me that it is fully ſaturated.

48. Let us ſuppoſe, for example, that the tube (fig. 24) was divided only into 27 equal parts; and that the ſaturation of the dephlogiſticated

giſticated air was compleated at the eighth diviſion of it: this ſhews that 19 parts [27—8 =19], equal to 38 of thoſe marked in the ruler, have been thrown into the Eudiometer; that is to ſay, that the whole bulk of both kinds of air is equal to 200 [= 162 + 38] meaſures, as thoſe marked by the ruler (fig. 11,) already explained No. 30. Now if the remaining quantity of air within the Eudiometrical tube is only equal to two meaſures or numbers of the ruler, it is clear that ſuch dephlogiſticated air is ninety-nine times of an hundred $\left[\frac{200-2}{200} = \frac{188}{200} = \frac{99}{100}\right]$ pure air; ſince its bulk is reduced, by the combination of *nitrous air*, to the $\frac{1}{100}$ of the whole.

49. It is but three days ago (*l*) that you ſhewed me ſuch a wonderful kind of air, as I have exemplified in the preceding number. This air you have produced before my eyes, from a ſolution of *quickſilver* and *nitrous acid*,

(*l*) This additional article to the preſent letter was wrote on the 16th of September, 1777; although the greateſt part of it has been written many months before, and the firſt twenty numbers were already printed: but ſome circumſtances, the knowledge of which cannot intereſt the public, have hindered the publication of the whole till this preſent time.

made

made many months before, and then diſtilled in a long but narrow glaſs retort, with a ſand-heat. This is, perhaps, indeed, an extraordinary phenomenon, and ſeems to bring us a little nearer to the door of the ſecret laboratory of Nature in the formation of air.

50. I cannot ſay, but ſo pure a *dephlogiſticated air* may ſtill be produced by this proceſs; that its whole bulk may be reduced to nothing by a proper combination with *nitrous air*. If ſo, what ſhall we then be able to think of a fluid ſubſtance, which is coercible in a glaſs veſſel, to which above the double quantity of another ſubſtance [$\frac{146}{54} = 2,7$], likewiſe coercible in a glaſs veſſel, being added; both theſe ſubſtances to appearance wholly vaniſh!

51. This phenomenon certainly deſerves the attention of philoſophers: and I gladly leave to them the examination of it. I muſt only add, for their information, that the *nitrous acid* is the thing chiefly concerned in its production: when this admirable ſubſtance acts on certain kinds of bodies, as *quickſilver* in the preſent caſe, its ſolution produces that *elaſtic*, but *coercible* fluid, which we call *nitrous air*: the reſiduum, after a long while, being properly urged by fire, gives at laſt the other *elaſtic*, but likewiſe *coercible* fluid, which we call

call *dephlogiſticated air:* and the combination of both, nearly in the above proportion, produces the wonderful phenomenon I have ſpoken of.

52. I ſhall ſay no more on this matter; and leave it very willingly to be conſidered and unravelled by abler philoſophers than I can pretend to be: and conclude the ſubject of this letter by aſſuring you, that I ſhall be very happy, if the things here treated of ſhould deſerve your approbation: and ſtill more ſo, if they produce the deſired effect I aim at, —the general good of mankind. I am, with the utmoſt regard and ſincere friendſhip,

My dear Sir,

Your moſt obedient and

Affectionate ſervant,

Bowood Park,
January 3, 1777.

J. H. de MAGELLAN.